



Review

Nickel in the Environment: Bioremediation Techniques for Soils with Low or Moderate Contamination in European Union

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Abstract: The review deals with the environmental problem caused by low or moderate nickel concentrations in soils. The main effects of this potentially toxic element on the soil biota and the most common crop species are addressed. Moreover, the paper emphasises biological remediation methods against nickel pollution in European soils. The focus is on the well-accepted phytoremediation strategy alone or in combination with other more or less innovative bioremediation approaches such as microbial bioremediation, vermiremediation and the use of amendments and sequestrants. Results acquired in real field and laboratory experiments to fight against nickel contamination are summarised and compared. The main objective was to evidence the ability of the above natural techniques to reduce the nickel concentration in contaminated sites at a not-risky level. In conclusion, the examined works agree that the efficiency of phytoremediation could be implemented with co-remediation approaches, but further studies with clear and comparable indices are strongly recommended to meet the challenges for future application at a large scale.

Keywords: nickel; agricultural soils; bioremediation; phytoremediation; microbial remediation; metal sequestration; vermiremediation; co-remediation

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1. Introduction

Potentially toxic elements (PTEs) in soils come from natural and anthropogenic sources; in agricultural areas, excessive application of PTE-containing products such as pesticides and fertilisers could lead to soil contamination [1–3]. PTEs include metals and metalloids, among which micronutrients such as nickel (Ni) are fundamental elements for the life of organisms, which, beyond certain thresholds, are toxic [4,5].

Soil contamination by PTEs is a growing global crisis affecting the environment and human health; there are approximately 3,000,000 contaminated sites in the European Economic Area [6].

Following Tóth et al. [7], most European agricultural land can be considered adequately safe for food production, and only 6.24% needs local assessment and eventual remediation action. However, in detail, the threshold value, i.e., the value that indicates the need for further evaluation of an area, is exceeded by more than 70–80% in many places, especially in the Mediterranean countries (Spain, France, Italy and Greece). Therefore, the remediation of PTE-contaminated soils is a priority for governments, scientists and environmental regulatory agencies [8].

At the European level, there is large variability between countries regarding the regulatory standards for heavy metals or metalloids in agricultural soils. For example, the threshold values for cadmium, mercury, lead and nickel range from 0.5 to 20, 0.5 to 80–40 to 750 and 30 to 300 mg kg⁻¹, respectively [9]. Generally, the limit values indicated by the Finnish regulations are used in international assessments on soil contamination by metals, as they have resulted from years of discussions and are considered the most representative [10]. The Ministry of Environment of Finland states the “threshold value” for Ni is 50

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